Winter 2006-2007 Forecast

For southwest Lower Michigan

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The National Weather Service official 2006-2007 winter forecast for all of southwest Lower Michigan indicates there is an enhanced probability for above normal temperatures from December 2006 through February 2007. The probability of warmer than normal temperatures is highest north and west of a line from South Haven to Big Rapids to Reed City. There was not enough information available to support a forecast for above or below normal precipitation or snowfall for southwest Lower Michigan.

Winter Normals

The following tables are based on the 1971 to 2000 Normals for December through February at selected locations in southwest Lower Michigan.

	Grand Rapids	**Muskegon**	**Lansing**
Average Max Temperature	32F	32F	32F
Average Min Temperature	18F	19F	16F
Mean Temperature	25F	26F	24F
# of days with Max Temperature below 32 F	57F	56F	57F
Total Precipitation (rain and snow)	6.26”	6.44”	5.23”

Table 1. 1971-2000 Normals for December through February

	Grand Rapids	**Muskegon**	**Lansing**
Total Snowfall (July 1st through June 30th)	72”	106”	55”
Mean Date of First 1” snowfall	Nov. 17	Nov. 17	Nov. 20
Mean Date of First 3” snowfall	Dec. 2	Nov. 29	Dec. 10
# of days with at least 1” of snowfall	17	29	20
# of days with at least 3” of snowfall	6	13	4
# of days with at least 6” of snowfall	1	3	1

Table 2. 1971-2000 Snowfall Normals for December through February

Forecast Reasoning:

The 2006-2007 winter forecasts for temperature (Fig. 1) and precipitation (Fig. 2) were based largely on both the Southern Oscillation and the recent trend of the temperature and precipitation anomalies. The Southern Oscillation is the Sea Surface Temperature (SST) anomalies that occur over the Tropical Pacific Ocean between 5 degrees north and 5 degrees south of the equator. It consists of three phases: El Niño (featuring anomalously warm SSTs over the eastern tropical Pacific Ocean), La Niña (featuring below normal SSTs over the central and eastern tropical Pacific Ocean), and the neutral phase (featuring near normal SSTs over the tropical Pacific Ocean). The normal phase occurs most frequently. The temperature trend is the difference between the mean temperature of the previous 10 years and the mean temperature for the 30 year climatology period (1971 to 2000). For precipitation, the trend is the difference between the previous 15 years for precipitation and the mean precipitation of the same 30 year climatology period.

Other factors considered in this forecast by the Climate Prediction Center (CPC) were the objective consolidation tool (called CON by CPC forecasters). The "CON" tool uses various statistical and dynamical forecast tools to help the CPC forecaster determine the impact of El Niño on the current weather trends. Beyond that, CPC considers the tropical 30 to 60-day Madden-Jullian Oscillation (MJO), which may affect climate variability within the winter season, the North Atlantic Oscillation (NAO) and the Pacific North American (PNA) patterns, which affect the temperature anomaly pattern, especially during the cold seasons. Snow and ice cover anomalies during the fall and winter are also a consideration the seasonal forecast.

The ENSO factor in this winter's forecast

As of early November 2006, the ENSO index showed a weak, but developing El Niño. Based on the development up to this point, the normal progress of events would suggest a moderate El Niño event should be progress during this coming winter. However, computer model forecasts suggest the El Niño event more than likely will remain weak through winter. Based on current conditions in the tropical Pacific Ocean and the general warming trend observed during the past few months, this episode is expected to strengthen and may reach moderate strength during the upcoming cold season. The greatest impact on the climate of Michigan from this event will be a greater than normal chance for above normal temperatures (Fig. 1) for the months of December through February.

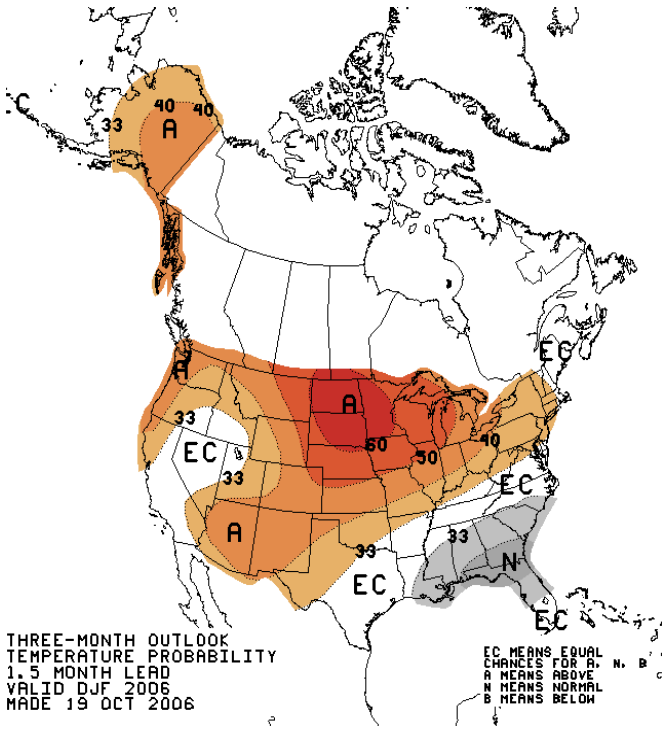

Fig. 1. CPC December 2006-February 2007 Temperature Forecast

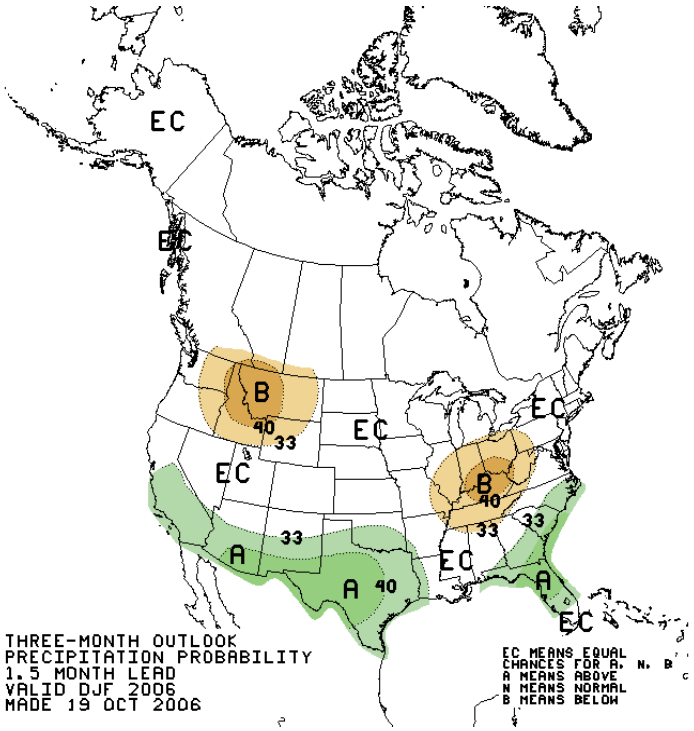

Fig. 2. As in Fig. 1, except for Precipitation

The Trend Factor in this winter's forecast

Figure 3a shows the trend for the winter temperature across the contiguous lower 48 states by comparing the winter mean temperature from 1995 to 2004 to the normals period of 1971 to 2000. Almost the entire lower 48 states experienced warming during the 10 most recent winters. This warming trend is factored into the ENSO forecast. Thus, if an area normally had a cold winter during a weak El Niño, the warming trend is added to the cooling influence of El Niño, which results in a cancelling effect. In this particular case, moderate or strong El Niño events already suggest an enhanced probability of above normal temperatures for Southwest Lower Michigan, which agrees with the trend and makes a better case for a warmer winter.

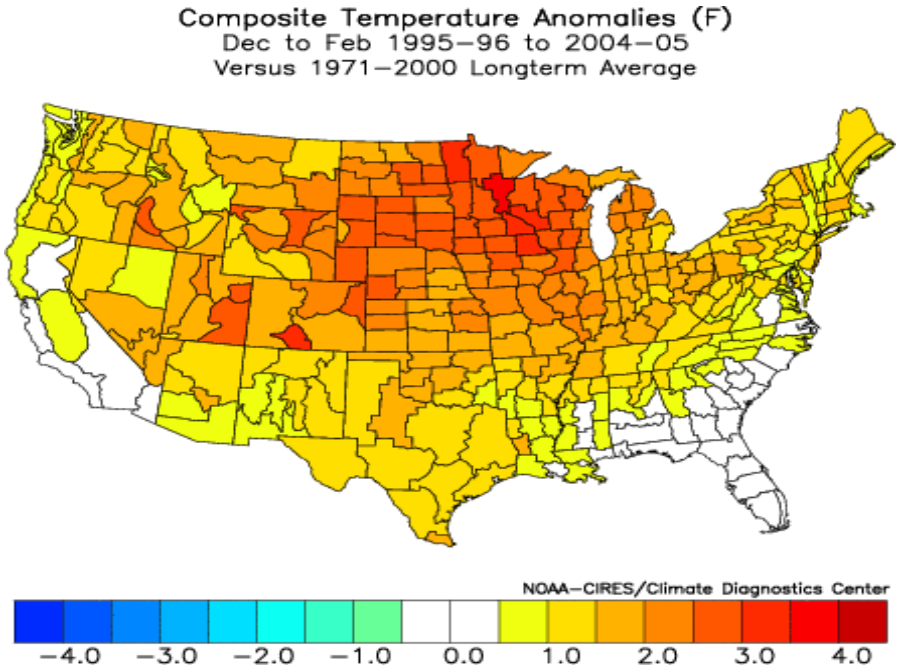

Fig. 3a. Climate Trend for Temperature.

While there is no significant trend in the total precipitation (Fig.3b) for Lower Michigan during the past 15 years compared the 1971 to 2000 climate normals period, there is trend toward a drier winter over the southeast United States and stronger trend toward wetter winters over eastern Oregon and most of Californian. In this case there is no "trend" to adjust the El Niño precipitation signature for southwest Lower Michigan.

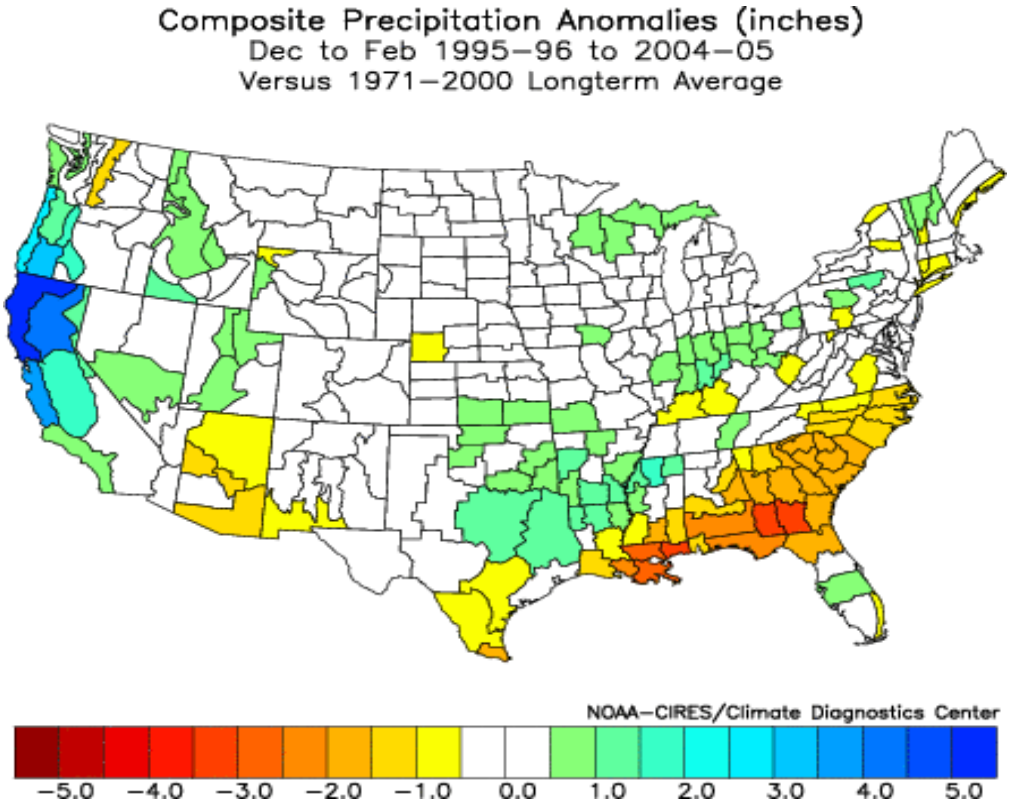

Fig. 3b. Climate Trend over the Past 15 Years for Precipitation. This chart compares the precipitation trend from 1991 to 2004 compared to the 1971 to 2000 normal period.

Impact of the NAO verses ENSO on southwest Lower Michigan's Winter Temperatures

Figure 4 shows the correlation of the winter air temperature to the NAO index. For southwest Lower Michigan, the correlation is about 0.5. Any correlation of 0.3 or higher is considered significant. The NAO correlation is stronger than the 0.3 correlation observed with ENSO (Fig 5), which is has a correlation of 0.3 for Southwest Lower Michigan. Since the NAO index infers a particular persistent circulation pattern and since it has the highest correlation of the indices used to monitor low frequency circulation patterns, it is the NAO pattern that most closely explains the character of a particular winter in southwest Lower Michigan. Unfortunately, there is little skill with using the NAO to forecast beyond 2 weeks.

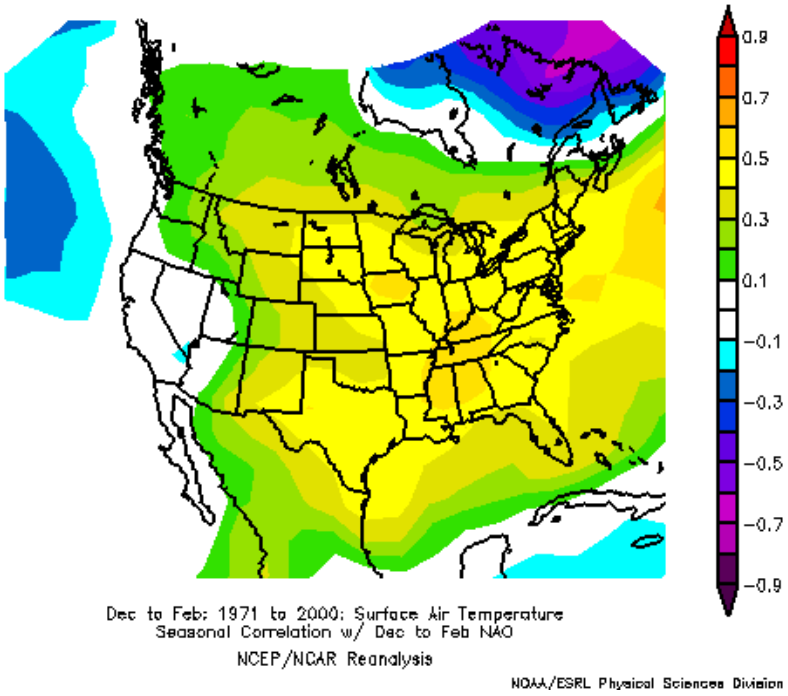

Fig. 4. Correlation between the NAO index and the Winter Air Temperature

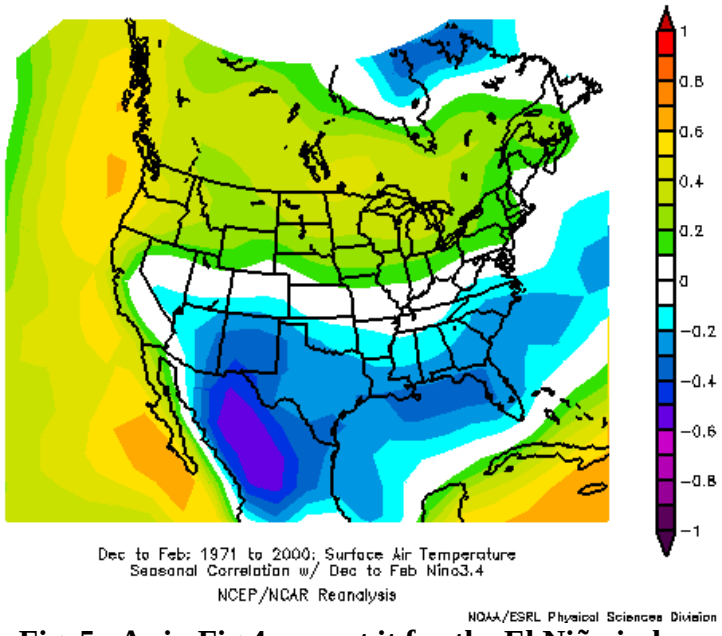

Fig. 5. As in Fig 4, expect it for the El Niño index

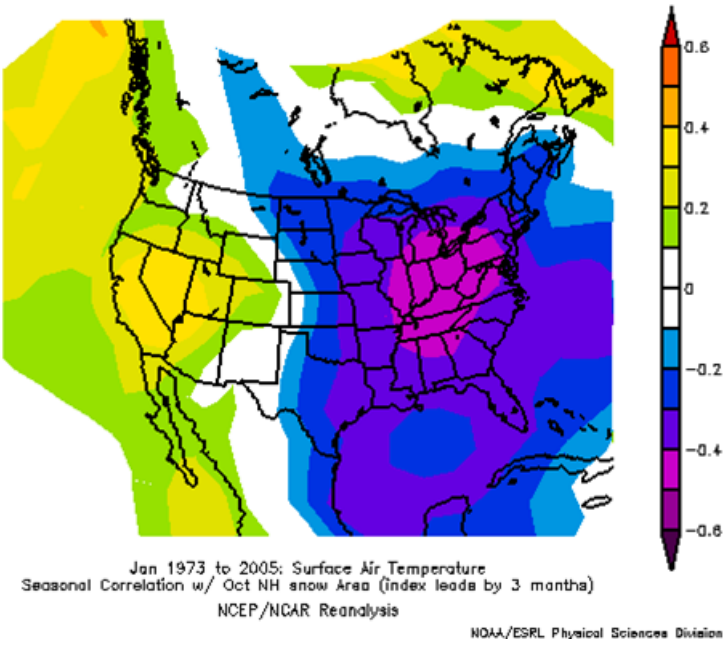

Fig. 6. October Northern Hemisphere Snow Area correlated with January Temperatures

Impact of Snow Cover on Winter Temperatures in Southwest Lower Michigan

Figure 6 shows the correlation between the October Northern Hemisphere snow cover area and the January surface air temperature. There is a strong negative correlation of around 0.50 over southern Lower Michigan and northern Ohio Valley, meaning that an increase in October snow cover is closely tied with below normal temperatures. Research has shown that early season snow cover does have an impact on jet stream patterns. This same research suggests that snow cover later into the winter season does not have as much of an impact on driving the jet stream. The snow cover area at the end of this October was larger compared to last year (Fig. 7), which by itself would suggest a slightly cooler winter compared to the winter of 2005-2006.

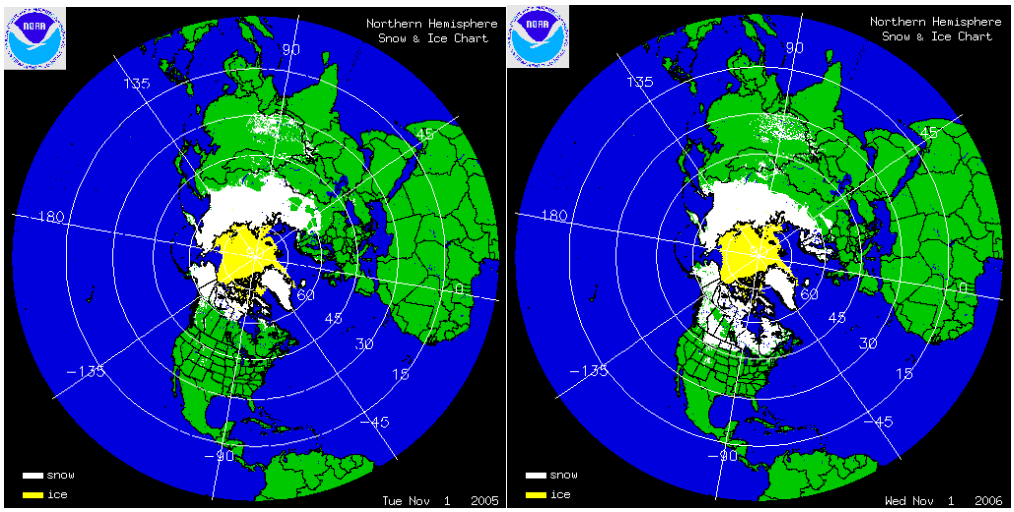

Fig.7. Snow cover on November 1st 2005 and November 1st, 2006

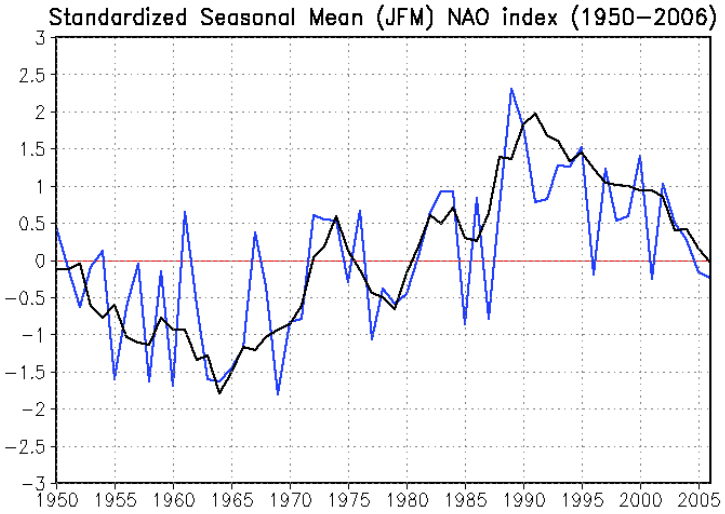

Fig. 8. Winter NAO Index from 1950 to 2006

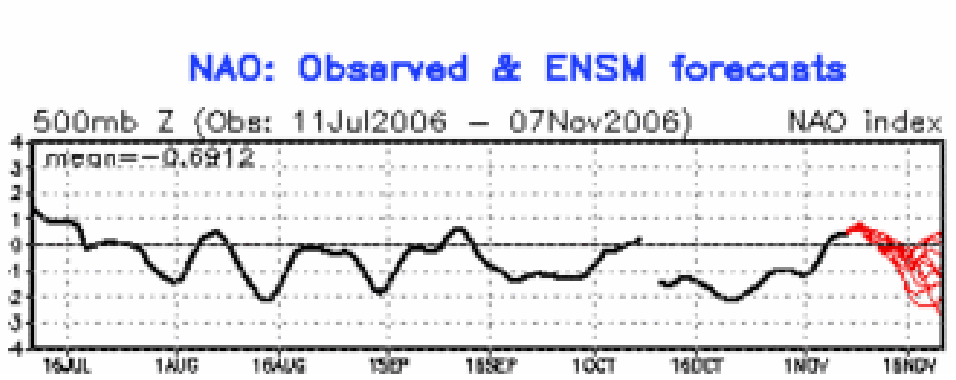

Fig. 9. NAO Index since July 2006

Figure 8 shows the trend in the winter NAO index from 1950 through 2005. Figure 9 shows the NAO index trend since the 11th of July, 2006 through the 7th of November, 20006 and forecast through the end of November. There has been a trend toward a negative NAO since the early 1990s (Fig. 8). The NAO was mostly negative from the 1950s through the mid 1980. It was during that time that southwest Lower Michigan had mostly cold winters. When the NAO was positive from the mid 1980s through last winter, most of the winters in southwest Lower Michigan were warmer than normal. This is reflected in the strong correlation of the NAO index to southwest Lower Michigan winter temperature anomalies (Fig. 4).

Figure 9 also shows the NAO index was mostly negative from mid-September through early November. That was a cold period in southwest Lower Michigan. The months of September and October were the first time since the summer of 2004 that southwest Lower Michigan saw 2 consecutive months with below normal temperatures. This underscores the strong correlation between the NAO phase and the temperature anomalies over southwest Lower Michigan. The NAO factor by itself would suggest an increased chance for colder than normal winter in southwest Lower Michigan.

Combining the effects of the NAO, the increase in fall Northern Hemispheric snow cover, the impact of a moderate El Niño, and the overall trend toward warmer than normal winters that started in the early 1990s, we expect a warmer than normal winter, but not as warm as last winters overall +3.3 F deviation from normal.

The Probability of Exceedance for Temperature and Precipitation

Using information from the various forecasting tools, CPC devised a tool called the Probability of Exceedance (POE; Fig 10). The areas in red are predicted to have greater than a 33% chance for above normal temperatures. Areas in white have approximately equal chances for above, below, and near normal temperatures. There is no area with an enhanced chance for a colder than normal winter. Figure 10 indicates southwest Lower Michigan's temperature has a 50 percent chance of being at or above the forecasted 1.5 F above normal and a 50 percent chance of being below the forecasted 1.5 F above normal. For both temperature and

precipitation, above normal is the top 33 percent of 1971 to 2000 winter values, normal is the middle 33 percent of the values, while below normal is the bottom 33 percent of those values.

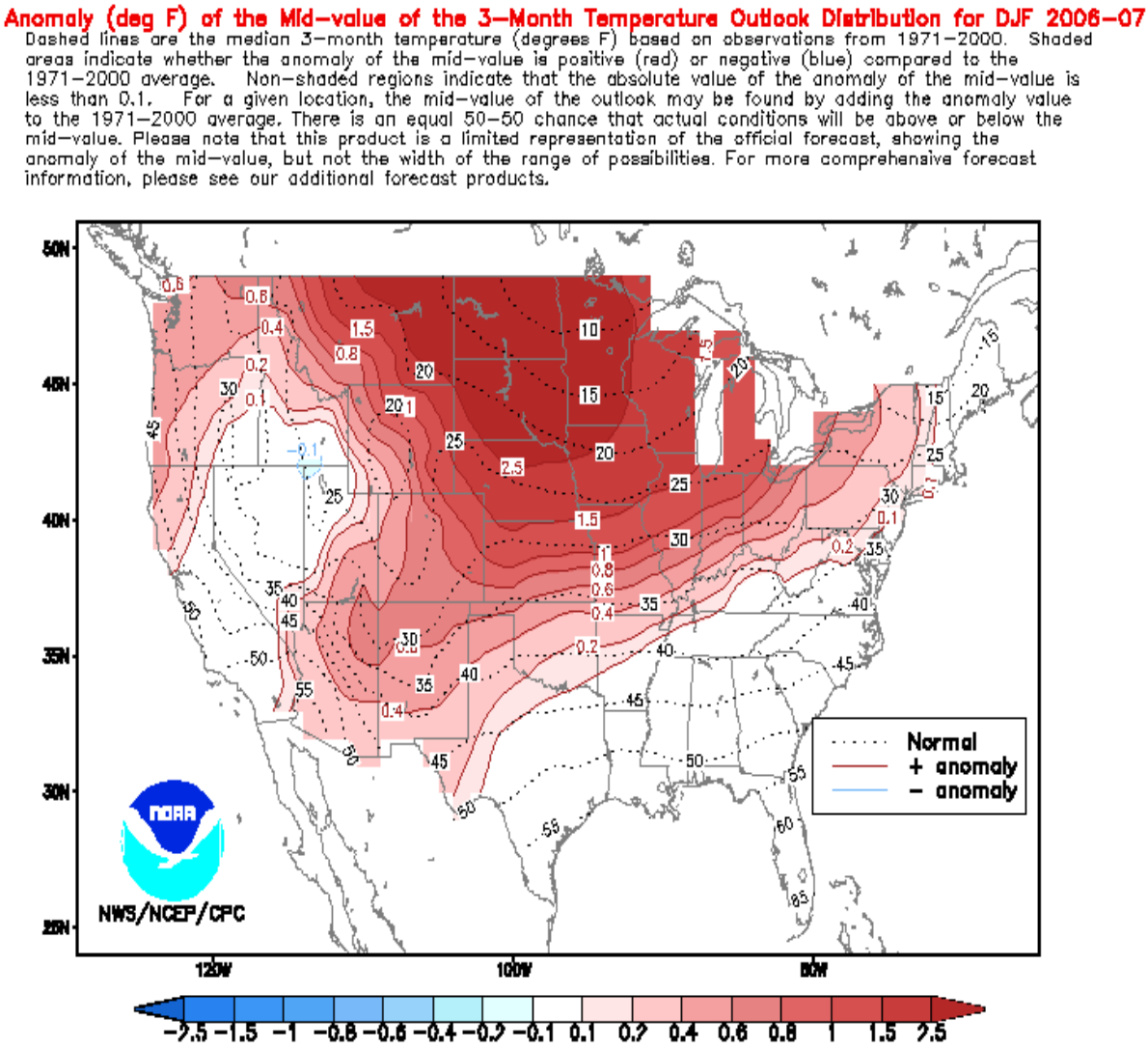

Fig. 10. The most likely category of the winter temperature anomaly across the Continental United States. Solid lines are the temperature anomaly values at which there is an equal chance of being above or below the value. Dashed lines represent the normal mean temperature.

Looking at the precipitation forecast using the POE tool (Fig. 10), areas with an enhanced chance of above normal precipitation are shown in green. An area where the forecast suggests there is an enhanced chance for below normal precipitation is shown in brown For southwest Lower Michigan, there is neither an enhanced chance for above normal or below normal

precipitation. That would imply a 50 percent chance of the total precipitation being above the normal value and a 50 percent chance of it being below the normal value.

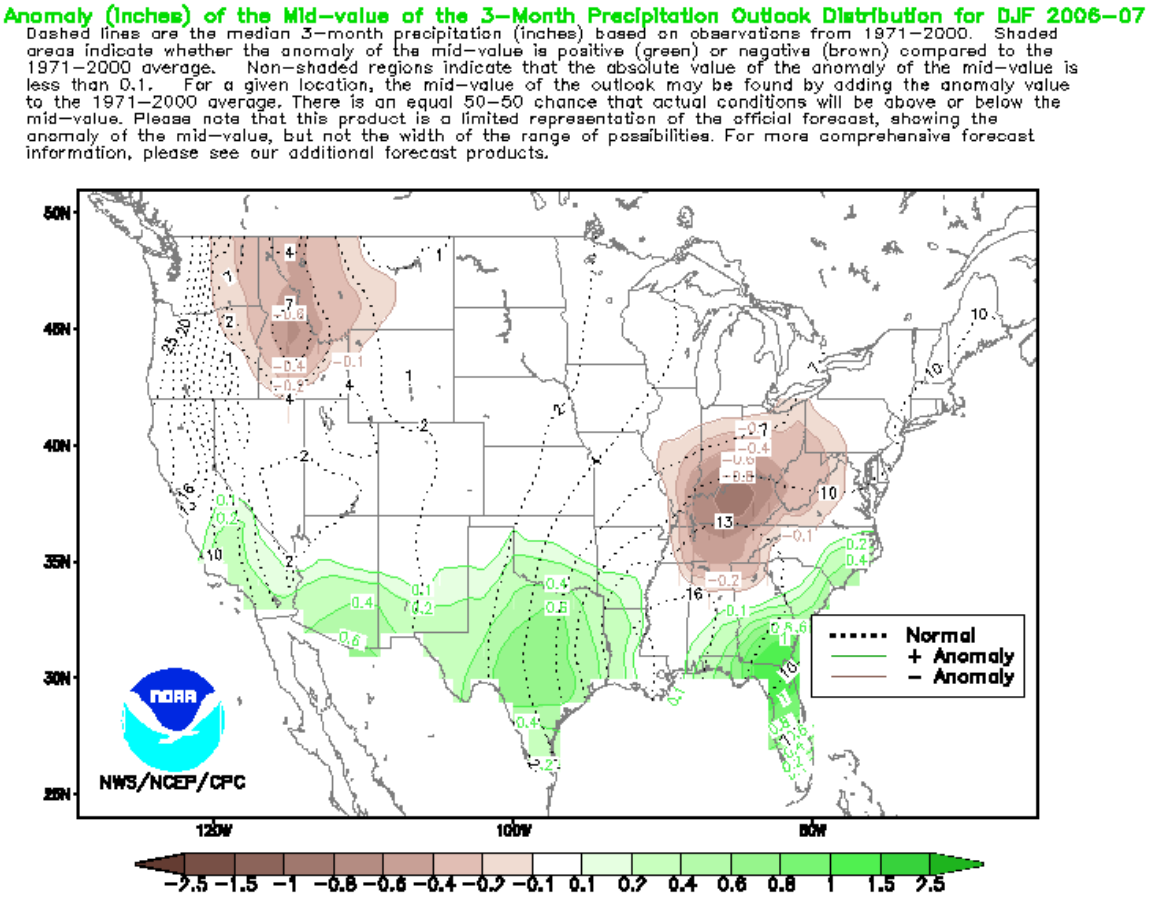

Fig. 11. The image above is the mostly likely category of the winter precipitation anomaly across the Continental United States. This chart shows there is an enhanced probability for above normal temperatures west of the Mississippi River while areas east of the Mississippi River show no significant adjustment to the normal winter temperature (dashed lines).

Local Information

Temperature Forecasts

The outcome of the temperature anomaly for this winter will largely depend on how strong an El Niño event there is. Figure12 shows Grand Rapids winter temperature anomalies based on the strength of the El Niño event. Figures 13a and 14a show the national impact of

weak and moderate El Niño events. In southwest Lower Michigan, weak events favor a colder winter while moderate or strong events favor a warmer than normal winters.

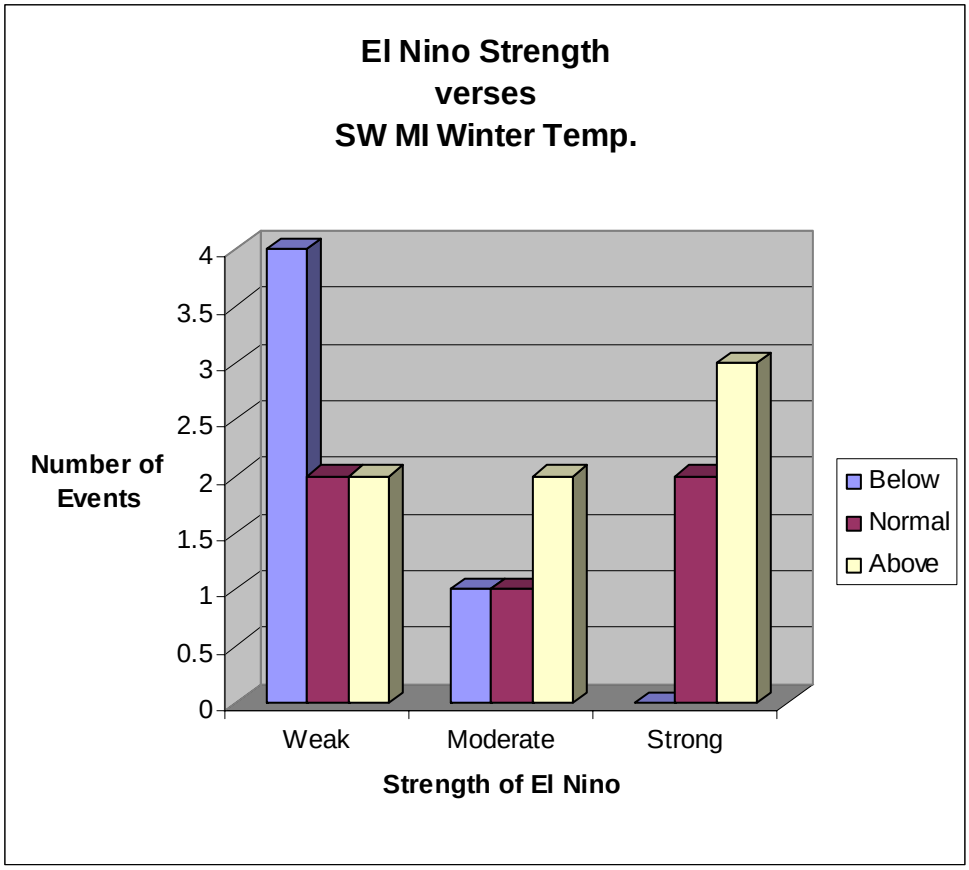

Fig. 12. Grand Rapids Winter Temperature Anomalies as a Function of ENSO Strength

Weak El Niño Events

Figure 13a shows the impact of a weak El Niño event on the temperature over the lower 48 states. Most of the eastern three quarters of the lower 48 states typically experiences below normal winter temperatures during weak El Niño events. Fig. 12 and Fig. 13a both suggest weak El Niño events would give southwest Lower Michigan a colder than normal winter. Note that Figure 12 shows colder than normal winters occur twice as often as warm or normal winters if there is a weak El Niño during the winter months. For all recorded weak El Niño winters, average temperature was 1.8 F below normal.

Weak El Niño Winter Composite Charts:

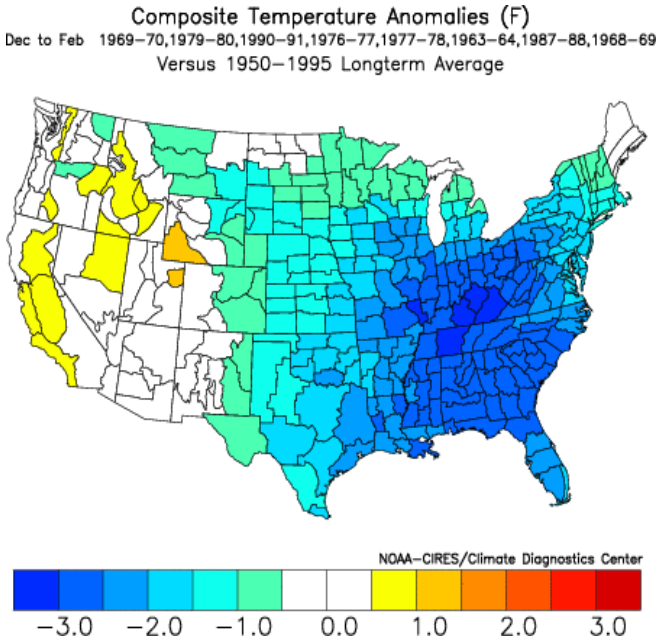

Fig. 13a. Weak El Niño and Temperature

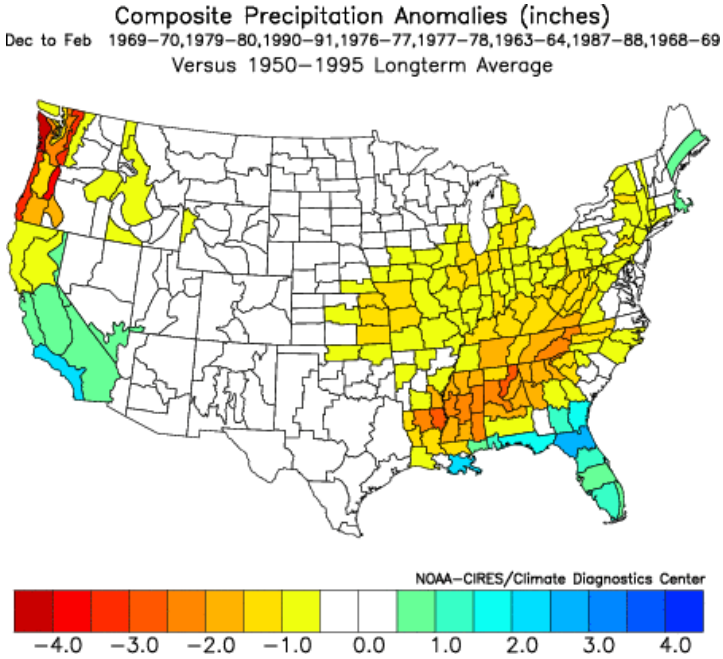

Fig. 13b. Weak El Niño and Precipitation

Moderate El Niño Events

Moderate El Niño events result in significantly warmer winter weather for the western Great Lakes (Fig. 14a), as compared the cool winters that are more typical of weak El Niño events. The warmest winter during a weak El Niño, the winter of 1990/1991 was about 2.1F above normal at Grand Rapids, while the warmest winter during a moderate El Niño event, 1986/1987 was 3.4F above normal. The coldest winter during a moderate El Niño was 2.6F below normal in 2002/2003, while for a weak El Niño there were three winters colder than 3F below normal. The winter of 1976/1977 averaged 6.8F below normal. The average departure from normal for moderate El Niño winters is 1.1F above normal, which is 2.9 F warmer than the mean departure for a weak El Niño winter.

Moderate El Niño Winter Composite Charts

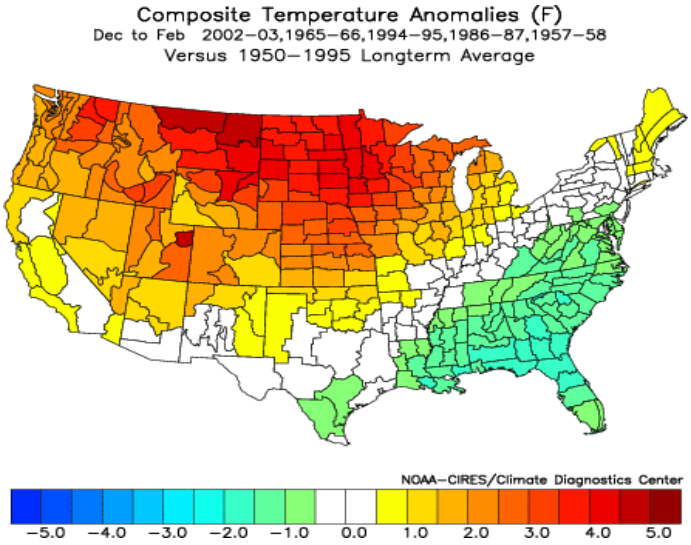

Fig. 14a. Moderate El Niño and Temperature

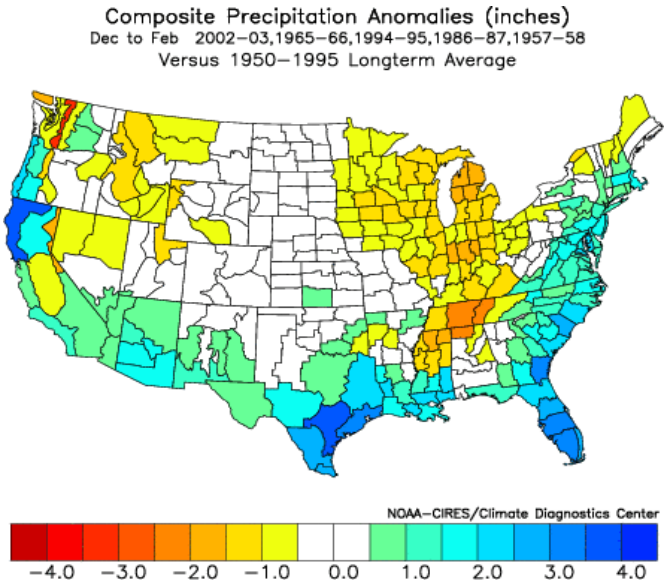

Fig. 14b. Moderate El Niño and Precipitation

El Niño Effect on Total Precipitation in southwest Lower Michigan

Total winter precipitation is below normal in both weak (Fig 13b) and moderate (Fig. 14b) El Niño cases, with the moderate El Niño cases being slightly drier. Weak El Niño winters average 1.4 inches below normal for total precipitation and have been below normal 4 out of the 7 weak El Niño winters recorded. Moderate El Niño cases average 1.5 inches below normal, and 60 percent of the moderate El Niño winters recorded were dry with precipitation at least an inch below normal. This would imply if we did have a moderate El Niño during the winter; a dry winter would have the highest probability. Since we are not sure if this will be a weak El Niño or a moderate El Niño winter, and because the weak El Niño cases do not have a strong correlation to a dry winter, there is not enough evidence to support either above or below normal precipitation for the coming winter.

El Niño Effect on Snowfall in southwest Lower Michigan

Fig. 15 shows the impact of El Niño strength and total seasonal snowfall. No El Niño scenario seems to prefer above normal snowfall. In the weak case, both near normal and below normal snowfall have equal probabilities. For the moderate El Niño events, below normal had a 50 percent probability, while near and above normal were 25 percent each. In the case of the strong El Niño, there was a 40 percent chance of below normal snowfall, a 40 percent chance of near normal snowfall and a 20 percent chance of above normal snowfall. However none of these results is statistically significant, so it is not possible to conclude snowfall amounts based on El Niño strength.

The Relationship of October Snowfall to the rest of the winter

Figure 15 shows some correlation between measurable snowfall in Grand Rapids in October, and snowfall for the rest of the season. Of the 116 years of October snowfall data for Grand Rapids, there was measurable snow only 22 percent of the time. When there is at least a tenth of an inch of snow in Grand Rapids in October (54 percent of the time) snowfall for the entire season is below normal. Only 23 percent of Octobers with measurable snow are followed by above normal snowfall for the entire season.

The outcome is similar for years when there was an inch or more of October snow in Grand Rapids. There is still only a 23 percent probability of above normal snowfall. The chances of near normal snowfall are slightly larger at 31 percent, and the probability of below normal snowfall drops to 46 percent. In both the measurable and one inch October snowfall cases, below normal snowfall for the season is the most common outcome. Similar results were also seen at Muskegon.

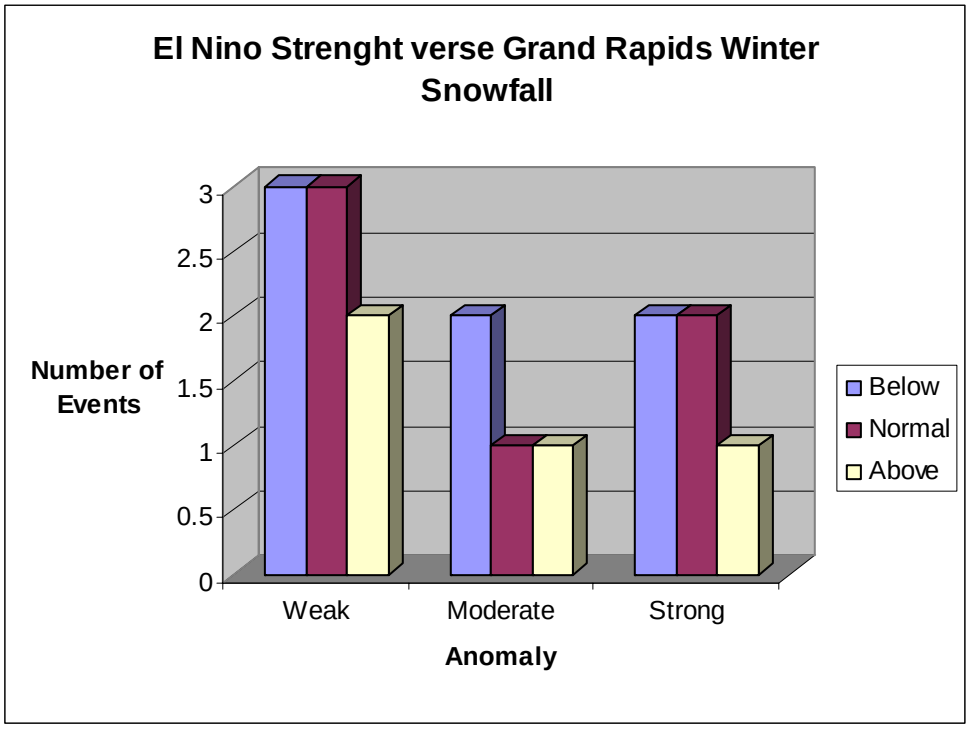

Fig. 15. El Niño Strength and Grand Rapids Snowfall

Snowfall Forecast Put Together

From 1995 to 2005, Grand Rapids had above normal snowfall 7 of those years, or 64 percent of the time. The same is not true across the rest of western Lower Michigan. However, the tendency for below normal snowfall with El Niño events does seem to apply to the rest of western Lower Michigan. Once again, a composite analysis does not show any outcome to be

statistically significant. This results in a forecast of equal chances for below, near, or above normal snowfall.

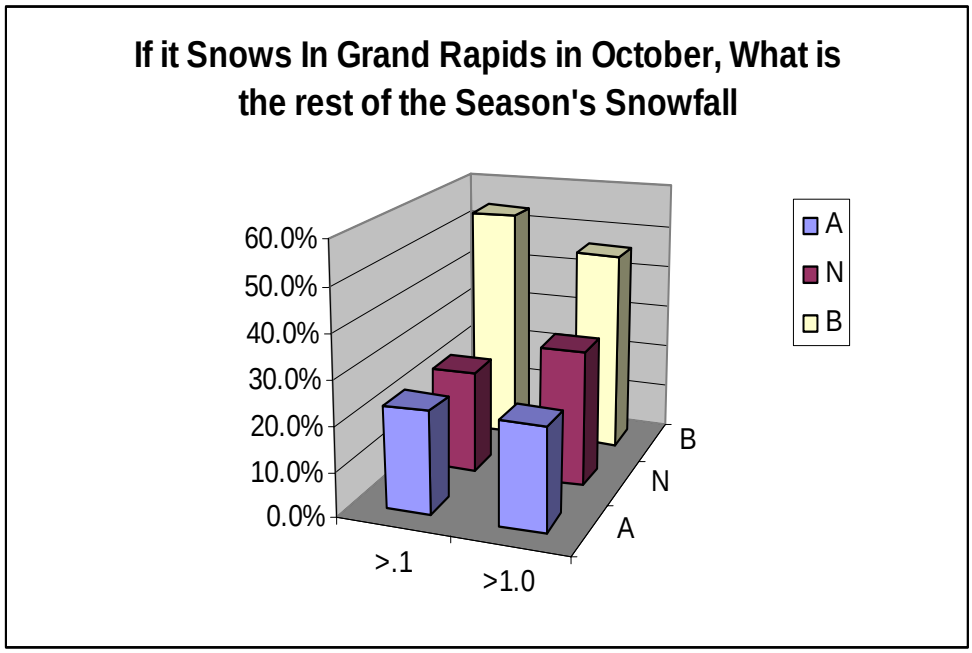

Fig. 16. Correlation of Grand Rapids October snowfall to seasonal snowfall.

Summary:

The most likely outcome for this winter in southwest Lower Michigan is for above normal temperatures. While we do expect a warm winter, it should not be as warm as the previous winter experienced from 2005-2006. There is a weak tendency for precipitation and snowfall to be below normal during El Niño events in western Michigan, but given the weak correlation and the uncertainty in the strength of the El Niño event expected this winter, there is little confidence in forecasting precipitation and snowfall anomalies this winter. Thus, we expect an equal chance for above normal, near normal or below normal precipitation and snowfall for southwest Lower Michigan.

For further information, please visit: http://www.crh.noaa.gov/climate/